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Environmental Effects of Coping Strategies Employed by Small Scale Farmers to Mitigate for Rainfall Variability in Bunyala Sub-County, Kenya

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Abstract

Farmers in Bunyala sub-county depend on rain fed agriculture and over the years frequent floods and droughts, crop failures and water shortages have become common. Research has shown that small-scale farmers in the developing countries are more vulnerable to rainfall variability due to their high reliance on rainfed agriculture and poor coping capacity. However most studies so far have concentrated on climate-driven adaptive capacity in flood prone areas and arid and semi-arid areas and have not considered the effects on livelihoods and coping strategies to this climate driven changes, especially in areas with both floods and drought regimes like Bunyala sub-county. It is against this background that this study sought to examine the environmental effects of coping strategies employed by smallscale farmers to mitigate for rainfall variability in Bunyala sub-county, Kenya. Specifically, the study sought to identify the environmental effects resulting from the coping strategies employed by small scale farmers in Bunyala sub-county to counter the effects of rainfall variability. Household survey, key informant interviews and focused group discussions was used to obtain data on coping strategies and the environmental effects of such coping strategies. The study used questionnaire, interviews, focus group discussion and field observation as data collection tools. Bunyala Sub-County has about 15,245 households in six locations. Proportionate stratified sampling was used to select the required number of respondents. The stratification was based on the populations of six locations. A total of 384 households were randomly selected and sampled from the selected locations together with 11 key informants. Qualitative and quantitative data analysis techniques were used while the results were presented in tables, figures and charts. Findings of the study indicate that strategies adopted occasionally tend to have negative impacts on the environment thereby compounding farmer's problems further. The study recommends that coping practices must be promoted while simultaneously strengthening long-term, sustainable institutional responses to help households adapt to rainfall variations. There is need to promote livelihood diversification initiatives that enhance improved income generation at the same time ensuring they have minimal negative impacts on the environment.

Key Words: *Livelihood, Coping Strategies, Rainfall Variability and Smallscale farmers*

Introduction

Rainfall variability is a key constraint to agricultural productivity and economic growth in many developing nations. While rainfall variation and distribution patterns is a worldwide phenomenon, potential effects are not expected to be uniform; rather they are unevenly distributed, both between and within nations (Hunter, Salzman & Zaelke, 1998; O'Brien & Leichenko, 2000). Vulnerability to rainfall variability is a function not just of dependence on natural resources, but also of socio-economic and institutional factors which influence how climate variability ramifications unfold (Adger *et al.*,

2006). The most vulnerable are often the poor, politically disenfranchised and sidelined communities, who are among the first to experience the effects and least equipped to diversify their livelihoods activities (Eriksen, 2011; Mannke, 2011). As a result, low income persons dependent on subsistence farming will arguably face severe hardships because they have little flexibility to cushion potentially large shifts in their production bases (FAO, 2008; Ribot, 2010). Climate stresses particularly rainfall variability will push these populations over an all-too-low threshold into an insecurity and poverty that jeopardizes their basic human rights (Moser & Norton, 2001).

Coping to climate change and variability which encompasses rainfall variability across different geographical regions is widely acknowledged as an important component of any policy response. Thus, without coping and adaptation strategies, rainfall variability will push poor rural farmers on a razor's edge of survival, but with coping and adaptation, vulnerability can largely be minimized (Adams et al., 1998; FAO, 2008). Rainfall variability may result from natural internal processes within the climate system or from variations in natural or anthropogenic forces (Selvaraju and Baas, 2007). The United Nations Framework Convention on Climate Change (UNFCCC, 2007) have projected that climate change may have a permanent negative effect on the natural resource base upon which agriculture productivity thrives, especially considering that it is happening at a time of growing demand for basic human requirements such as food, and fuel. Agriculture is highly dependent on the rainfall variation and human dependence on agricultural livelihoods especially the poor is high (Slater *et al*., 2007).

Variation in rainfall is a reality in Kenya and people have begun to experience its impacts on their daily lives (IPCC, 2001). Rainfall variability and change has had far reaching effects in Majority of the Kenyan population depend on rain-fed agriculture. About 65% of Kenya's population depends on agriculture for food and income and the sector accounts for 26% to the Gross Domestic Product (GDP) and approximately 61% to foreign exchange earnings (Perret, 2006). A study by Kenya Meteorological Department (KMD) on temperature and rainfall trends in Bunyala Sub-county showed that climate change has an effect on temperature and rainfall. This was based on analysis of temperature and rainfall collected over a period of 42 years (KMD 2001).

Seemingly as the communities take measures to cushion themselves against rainfall variability some of the coping strategies end up impacting on the environment negatively. Studies have shown that unsustainable harvesting of sand and gravel from rivers results in adverse effects both onsite and offsite which eventually leads to changes in channel form, drying of river banks, and interference of both terrestrial and aquatic food forms (Starnes, 1983 and Sequier, 1997). Extraction of sand results in destruction of underground water aquifer and loss of water. Certainly, sand harvesting adversely affects water quantity and quality and damages the aquatic ecosystem. Sand transportation by large tracks leads to environmental degradation by increasing soil erosion and affecting soil structure and stability.

Ashraf *et al.*, (2011) asserts that stream mining can have other effects beyond the immediate mine surroundings. Many hectares of fertile land are lost, as well as valuable tree resources and wildlife habitats in the riparian areas. Degraded river habitats often results in loss of fisheries production and breeding, biodiversity because all species require specific habitat to consider and to ensure long-term survival, reduction in recreational potential and the value of land and its aesthetic values.

According to study carried out in Tamil Nadu India Saviour (2012) it was found out that the effects of sand harvesting on the environment may cause (i) the undercutting and collapse of river levees (ii) the loss of adjacent land and or embankments (iii) upstream erosion as a result of an increase in channel gradient and changes in flow speed and (iv) downstream erosion due to increased load carrying capacity of the river and downstream changes in patterns of deposition and changes in channel bed and habitat nature. Lawal (2011) did a study in Nigeria and found out that in stream sand mining results in the destruction of aquatic and riparian habitat through large changes in the channel structure.

The process of deforestation that is particularly common among rural communities due to limited livelihood strategies and a poor resource base end up producing many negative impacts of environmental consequences such as global warming, biodiversity loss and soil degradation which are identified (Mahapatra and Kant, 2003). On the part of climate change, it is noted that deforestation and forest degradation in developing countries are held to account for about 17% to 20% of increased greenhouse emissions (GHGs) that are responsible for global warming and climate change often resulting to rainfall variability in many parts of the world (Owusu *et al.,* 2011; TEEB, 2010, Insaidoo *et al,* 2012).

There is an established fact that there is a positive correlation between deforestation and global warming since forests, especially tropical forests are major players acting as carbon sinks (Gorte and Sheikh, 2010). The clearance of tropical forests in many countries means the collapse of major carbon sinks and generation of more carbon dioxide which is a possess threat to global climate change and atmospheric temperature distribution. Clearing of trees also leads to biodiversity loss and it seems plausible that biodiversity loss endangers production systems that though this is difficult to quantify especially for cross-ecosystem effects (Chomitz, 1999). Environmentalists have stated that that when trees are cut, the forest no longer supports the same biodiversity or maintains clean water as effectively as it did before and this may place its inhabitants at risk (Knox and Marston, 1998). Soil degradation particularly loss of soil fertility and nutrient loss is a known effect of the loss of forests to grasslands (Gabler *et al*., 2007).

The close relationship between deforestation and poverty of rural communities is an established narrative in the development discourse of developing countries (TEEB, 2010; Zwane, 2002; Kerr *et al.,* 2004; Pfaff *et al.,* 2008). This is attributed to increased deforestation resulting loss of livelihood assets and outcomes (loss incomes, employment, food, medicine, and energy) for most of the 400 million to 1.6 billion people in forest communities who directly and indirectly depend on forest resources for their survival (Owusu *et al.,* 2011; Mayers and Vermeulen, 2002). Since the survival of most households is dependent on these livelihoods it is likely to aggravate poverty which is often endemic among the rural poor.

Land uses are clearly responsible for a number of waste substances found in rivers. These pollutants include heavy metals, pathogens and toxins, each detrimental to the health of aquatic life. Organic pollutants are detrimental to ecosystem health as they are toxic and can cause biomagnification up the food chain. Sediments plants and animals of the benthos and reduce light penetration due to reduced light penetration (Water and Rivers Commission 1997). Chemicals and heavy metals can also be found within the river capable of causing illness and death of aquatic life.

Agricultural activities are a source of soil nutrients to both freshwater and marine ecosystems (Arbuckle & Downing 2001) the concentrations of which have been correlated to the percentage of agricultural land in its catchment area (Stalnacke *et al.,* 2003; Edwards *et al.,* 2000). Agricultural land use includes land used for cultivating soil, producing crops, raring livestock. Runoffs are examples of diffuse nutrient sources from agricultural land use which eventually end up polluting aquatic habitats (Hemond & Fechner-Levy 2000) it is worth noting that agricultural activities have great impacts upon the water quality of receiving water bodies (Gilvear *et al.,* 2002).

In Kenya the use of firewood in brick making industries usually leads to adverse environmental pollution and health problems. Effect of brick making on air pollution, vegetation and human health has been reported. It has been shown that brick industries cause air pollution and land degradation besides decreasing biodiversity and causing nutrient loss in plants/trees in immediate vicinity (Dwivedi and Tripathi, 2007). It has been noted that that the workers in brick industries are susceptible to respiratory diseases such as silicosis, pneumonocosis and musculoskeletal disorder. Brick kilns have been shown to affect ground water quality due to leaching of minerals (Datta., Deb and Tyagi, 1996). It is against this background that this study sought to examine the Environmental effects of coping strategies employed by

smallscale farmers to mitigate for rainfall variability in Bunyala sub-county, Kenya.

Statement of the Problem

Kenya like many other countries in Africa is highly susceptible to rainfall variability. The economy as well as the wellbeing of its people is dependent on rain fed agriculture, therefore an adverse a change in rainfall amount and distribution may mean increased food insecurity, soil erosion and land degradation, over flooding leading to damages in infrastructure and settlements and an outbreak of diseases like malaria (Twinomugisha, 2005). It is worth noting that Kenya in the recent years has been experiencing an increase in the frequency and intensity of extreme weather events with serious socio-economic consequences. The country has experienced seven severe droughts over the period 1991-2008, affecting over 35 million people who required immediate humanitarian assistance (CIESIN, 2005). Agriculture is arguably the most vulnerable sector to drought, with crops affected badly if the drought occurs during the growing season. Any damage to the agricultural sector leaves the country exposed to hunger, famine and increase in disease incidence.

Research has shown that small-scale farmers in the developing countries are more vulnerable to rainfall variability due to their high reliance on rainfed agriculture and poor coping capacity. Farmers' efforts to cope have been wanting and cases of adverse environmental effects from the coping strategies have been reported and hence need to be examined. This study therefore sought to examine the Environmental effects of Coping strategies employed by small-scale farmers to mitigate for rainfall variability in Bunyala sub-county, Kenya with the aim of improving the understanding of rainfall variability and of measures of enhance coping strategies that are environmentally sustainable.

Objective of the Study

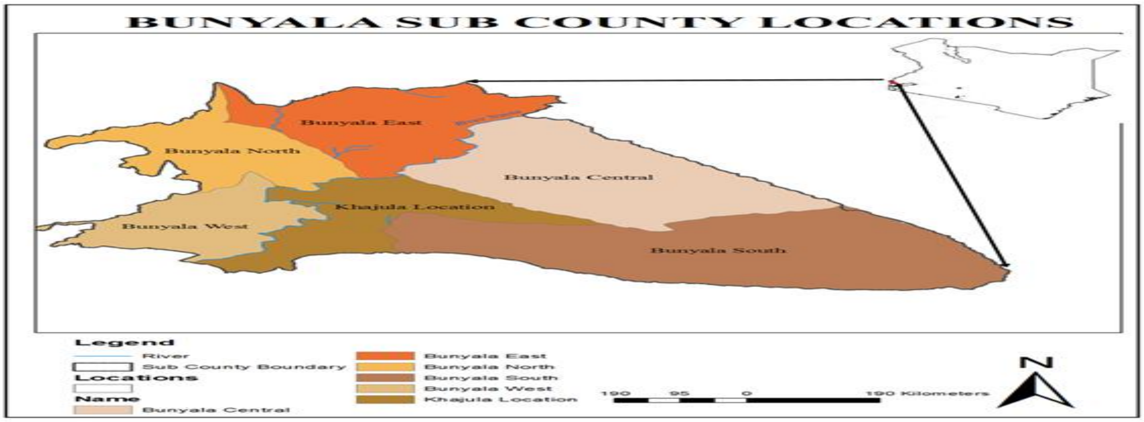
The study was guided by the following objective

1. Identify the environmental effects resulting from the coping strategies employed by small scale farmers in Bunyala sub-county to counter the effects of rainfall variability.

Research Methods and Materials

The design of the study was descriptive survey which allowed large amounts of data to be collected over a short period of time. It provided for numeric descriptions of the population. It also enabled the researcher to describe and explain relationships between dependent and independent variables. The broad research strategy used in this research is qualitative in nature. A qualitative methodology of inquiry is rooted in the phenomenological paradigm as opposed to the positivist school of thought (Corbetta, 2003). The phenomenological paradigm emphasizes understanding, analyzing and describing phenomena without necessarily relying on quantitative measurements and statistics (Dawson, 2007). In direct contrast to positivism, phenomenological approaches accept subjectivity as opposed to objectivity. Phenomenology also allows for interpretation of events and phenomena such as those identified in the study on livelihood coping strategies among small scale farmers to rainfall variability in Bunyala Sub-county, Kenya as opposed to strict quantitative measurements.

Bunyala Sub County was selected as the study area because of its positioning since it is a region characterized by small farm holdings averaging 2.4 acres per household and is a marginalized agricultural area due to exposure to rainfall variations where both extremes are experienced that is floods and drought respectively. Bunyala Sub County is a particularly useful case for illustrating a region that has to cope to the double exposure of floods and drought. The agricultural sector in the sub county is particularly exposed to economic pressures due to its marginal farming conditions that are not conducive to large-scale production. Various coping strategies are practiced by the community to cushion themselves against adverse weather conditons. People have settled near the dykes along the river in some locations and encroachment into flood plains for agriculture, livestock keeping and fishing.



Map of Bunyala Sub-County showing the study locations

Target population

The study targeted households drawn from the six locations that comprise the sub-county. A total of 15,245 households were used to arrive at the sample size in the entire sub-county as shown in Table 3.1. The choice of households was informed by the need to investigate rainfall variability as perceived by households rather than individual farmers. The unit of analysis was the household and therefore the study targeted a total of 15,245 household.

Distribution of Households in Bunyala Sub-County

Location	Area (Km^2)	No. of Households
Bunyala West	14.6	3521
Bunyala North	27.3	2710
Bunyala East	41.9	3318
Bunyala Central	47.7	2470
Khajula	20.1	1762
Bunyala South	36.8	1464
Total	188.4	15,245

Source: KNBS (2010)

The sample size for the present study was based on the margin of error approach derived from the central confidence interval for proportions (Tabachnick & Fidell, 2013). Consequently, a sample of 384 was therefore selected for the study. Both stratified and simple random sampling techniques were used to select the required 384 small scale farmers. First the sub-county was stratified in terms of the six locations. The number of farmers to be drawn from each location was proportionate to the population of households in each location relative to the entire sub-county.

Stratification of Sampled Households

Location	Number of house holds	Number in sample
Bunyala West	3521	$\frac{3521}{15245} \times 384 = 87$
Bunyala North	2710	$\frac{2710}{15245} \times 384 = 68$
Bunyala East	3318	$\frac{3318}{15245} \times 384 = 84$
Bunyala Central	2470	$\frac{2470}{15245} \times 384 = 62$
Khajula	1762	$\frac{1762}{15245} \times 384 = 44$
Bunyala South	1464	$\frac{1464}{15245} \times 384 = 39$
Total	**15,245**	**384**

Simple random sampling was then used to select the respective household heads from each location. All household heads in each location were assigned random numbers. Random number generation was then used to select the required number per each location. Gender sensitivity was considered by purposively targeting female headed households.

Three instruments were used in the data collection for the study these included household survey questionnaire, focused group discussion guide, and key informants interview schedules. The choice of three data collection instruments was informed by the need to triangulate data collection considering how sensitive findings from the study could be. In addition field observations were done practically by use of photographs. Consequently, collecting data from various sources using diverse instruments was ideal for more reliable data. Reliability coefficients of the six measurement scales used in the study were revealed that with the exception of opportunities and innovations (α=.625), all the other scales achieved the recommended reliability level of 0.7. This implies that the scales in question had a high degree of internal consistency among the measurement items. Although the reliability for opportunities and innovations fell below the 0.7 limit, it was above the minimum acceptable value of 0.6 (Hair et al., 2008). For this reason this scale was retained alongside the others.

Findings and Discussion

Environmental Impacts Resulting from Coping Strategies Adopted

Research objective sought to identify environmental impacts attributable to coping strategies that small scale farmers in Bunyala sub-county use. Investigation of environmental impacts experienced was conducted across small scale farmers using the farmers' questionnaire and focused group discussion and from environmental and agricultural experts

Environmental impacts of coping strategies used by farmers

Two items on the farmers' questionnaire targeted farmers' perceptions on environmental impacts of coping strategies. First, farmers were asked the effect of adjustment to weather changes has had on the environment. From the results of a concise survey of the six locations, it is apparent that coping strategies used by small scale farmers in Bunyala sub-county has had telling effects on the environment. Results shown below indicate that 69.7% of the farmers perceive that the coping strategies used have led to loss of soil fertility. Decline in tree cover was also perceived by 64.7% as a major environmental impact examples of tree species under threat include Markhamia luteau Albizia coriaria Mangifera spp Lanneas chweinfurthii Cassia siamea and Spidium guajava and omudodo tree (ficus spp). The results

showing decline in tree cover, loss of soil fertility and land degradation among others are consistent with previous findings attributed to rainfall variability (IPCC, 2004, Alok, 2005; William & Philip, 1999). These findings have in a way expounded the adverse effects of decline in tree cover in large areas. According to IPCC (2004), rainfall variability particularly in cases where deforestation exists has resulted in environmental impacts such as flood, soil erosion, climate change, biodiversity loss among others. The argument here is that by resulting to charcoal burning for instance, tree cover is depleted and this can be responsible for the visible land degradation.

Indeed, activities such as charcoal burning can be gainful in the short term, are also quite dangerous in the long run. Loss of tree cover has been alluded to global warming as well as the enhanced greenhouse effect (William and Phillip, 1999). According to intergovernmental panel on change (2000), deforestation could account for up to one third of total anthropogenic carbon dioxide emissions. The argument here being that charcoal burning as an activity releases much of the carbon stored in trees back to the atmosphere. Other key impacts perceived are land degradation (60.6%) and loss of crop variety (species) (45.7%). Farmer's mainly engaged in fishing activities pointed to interference with aquatic habitat leading to decline in fish (29.2%) as an impact being felt.

Farmer Perceptions of Environmental Impacts of Coping Strategies used

Impacts	% of farmers
Decline in tree cover	64.7
Loss of soil fertility	69.7
Loss of crop variety	45.7
Land degradation	60.6
Increased incidences of pests and crop diseases	24.8
Interference with aquatic habitat leading to decline in fish	29.2
Ploughing along the river bank	17.3

Farmers' perceptions are in accordance with several coping strategies adopted. Decline in tree cover for instance is a direct result of non-farm activities that target use of trees such as charcoal burning. Land degradation on the other hand results from several activities that tend to neglect farming for example keeping large herds of traditional cattle to cushion the farmers in case of loss during drought.

The desire to find out impacts of coping strategies on the environment is due to the need to minimize further degradation of several sectors. This is in recognition of findings that point to climate change and variability as one most serious threat to sustainable development with adverse effects on environment, human health food security and physical infrastructure (IPCC, 2007; Hug *et al.*, 2006).

The finding showing loss of soil fertility as a key environmental impact is expected under such extreme conditions. Requirement of soil nutrients exceeds their replenishment the consequence being a negative balance of nutrients. Besides, poor agronomic practices such as frequent fires are experienced in drought leading to a reduction in soil organic matter vital for nutrient conservation. This reflects views by Majule (1999) on declining soil fertility.

Agricultural institutions and NGOs views of environmental effects of coping strategies

In response to the question on the environmental effects of the coping strategies employed several effects came up which included soil fertility, soil degradation loss of biodiversity as shown on below

Agricultural institutions and NGOs Perceptions of environmental effects of coping strategies

Question	Themes	Sub-themes
What environmental effects have you observed from the coping strategies?	Continuous cropping	• Loss of soil fertility • Alteration of soil structure and microbial activity
	Intensive hillside Cultivation	• Soil erosion • Soil degradation
	Keeping large Herds of livestock	• Soil compaction and erosion • Degradation of grasslands • Increased runoff
	Use of inorganic Fertilizer	• Soil acidification • Contamination of river Nzoia water
	Sand harvesting	• Land degradation • Loss of biodiversity
	Cultivation along river Nzoia and sand harvesting on the riverbed	• Destabilization of river bank • Contamination of river Nzoia • Alteration of river channel flow

From the above results effects of environmental degradation are real and need to be addressed to ensure the coping strategies are sustainable.

The finding that land degradation is a key impact of strategies used to cope with rainfall variability is consistent with the reported impacts of weather changes on livelihoods in the area. Flooding features prominently among these impacts. Considering that geographically the area has sparse vegetation and low lying, implies decline in tree cover continues to expose the area more to flooding. This then requires that small scale farmers desist from depleting tree cover if some of the impacts of weather changes have to be addressed.

Studies have shown that unsustainable harvesting of sand and gravel from rivers results in adverse effects both onsite and offsite which eventually leads to changes in channel form, drying of river banks, and interference of both terrestrial and aquatic food chains (Starnes, 1983 and Sequier, 1997). Extraction of sand results in destruction of underground water aquifer and loss of water. Certainly, sand harvesting adversely affects water Quantity and quantity and damages the aquatic ecosystem. Sand transportation by large tracks leads to environmental degradation by increasing soil erosion and affecting soil structure and stability. The storage of sand causes destruction of the earth surface in areas through clearing of vegetation matter (Mbathi *et al.,* 1994). According to study carried out in Tamil Nadu India Saviour (2012) it was found out that the effects of sand harvesting on the environment may cause (i) the undercutting and collapse of river levees (ii) the loss of adjacent land and or embankments (iii)

upstream erosion as a result of an increase in channel gradient and changes in flow speed and (iv) downstream erosion due to increased load carrying capacity of the river and downstream changes in patterns of deposition and changes in channel bed and habitat nature. Sand harvesting done on lowlands of the sub-county has led to loss of biodiversity as well as making land derelict. Alternative form of livelihoods that are environmentally friendly should be encouraged.

The results are collaborated by observations made on the ground shown the plates below shows some coping strategies with negative impact on the environment.

Sand harvesting dangerous to the respondents

Source: Researcher

Derelict land and habitat loss as a result of sand harvesting in Bunyala central location

Source: Researcher

Firewood obtained from the nearby forest in Bunyala north

Source: Researcher

Plate 1: Harvested water reeds from river Nzoia Bunyala East location

Source: Researcher

Vegetable farming along the banks of river Nzoia

Source: Researcher

Plate 2: Large herd of cattle cause of grassland degradation

Conclusion

The current study also examined the environmental impacts resulting from strategies adopted by small scale farmers to cope with rainfall variability. Consequently, the study found out that among environmental impacts of coping strategies used are mainly loss of soil fertility; decline in tree cover, and land degradation. The study through field observations revealed that decline in tree cover, loss of soil fertility due to flooding and land degradation are major environmental impacts arising from coping strategies used.

Policy Implication

In order to mitigate challenges arising from rainfall variability, farmers use diverse strategies that are all inclusive and range from farm related and nonfarm related. Most of the farmers are low income earners and have to diversify activities to cope with extreme weather conditions. Strategies adopted occasionally tend to have negative impacts on the environment thereby compounding farmer's problems further. Activities such as charcoal burning are eroding tree cover which is then responsible for the dilapidated terrain. There is need to promote livelihood diversification initiatives that enhance improved income generation at the same time ensuring they have minimal negative impacts on the environment.

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